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# A Prototype Simulation Model for Army Logistics Training

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# Scope

- Background
- Problem Scope/Formulation
- Design and Validation challenges
- The prototype
- Next Steps

# Background

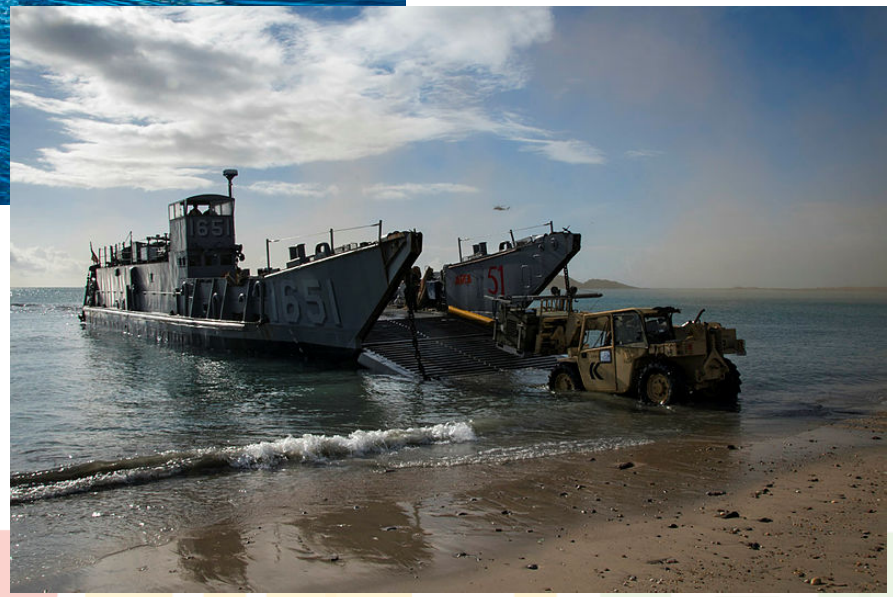
# Origin Story

- Army Logistics Training
  - Training stops at orders/writing the plan
  - Experiential deficit
  - No way to validate (or experiment) with planning
  - Deployment does not mean experienced
  - Result:
    - waste due to redundancy or
    - loss of freedom of action for combat commander

# Dynamic Complexity

- Learning challenges:
  - Long time frames between decision and feedback
  - Staff rotation on mission – execute someone else's plan
  - Shortfalls affecting mission outcomes are unacceptable
  - Highly complex systems with non-obvious information flows
  - Supporting multiple battles, even multiple theatres
- This Dynamic Complexity (Sterman) means difficulty in learning lessons from planning decisions

# Army does conduct simulation



# But...

- Army will always prioritise war-fighter training and simulation
- Combat focussed training/simulation does not meet logistic training needs
- Combat focussed training consumes logistic personnel and assets... So

- Serious games may be the most feasible way for Logistics planners to develop mental models

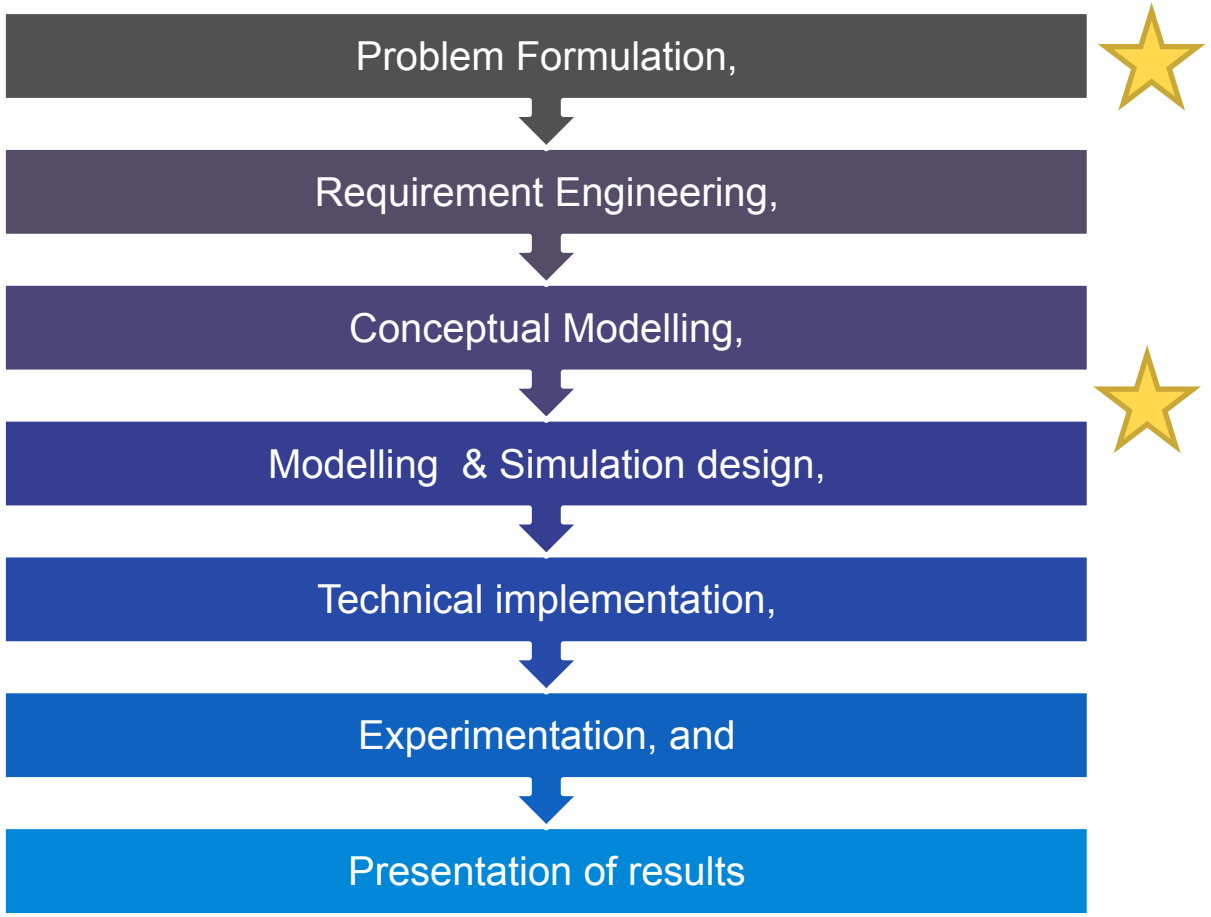
# Serious Game

- A well designed Serious Game also offers:
  - reduced personnel overhead, (ie no additional training, no additional staff to manage...)
  - capable of being operated and employed by luddite (military) staff and students... and
  - have engagement and fidelity of problem to overcome the inherent ~~arrogance~~ **psychological inertia** of military officers (users)

# And so: Project Caesar, A Serious Game


# Project parameters

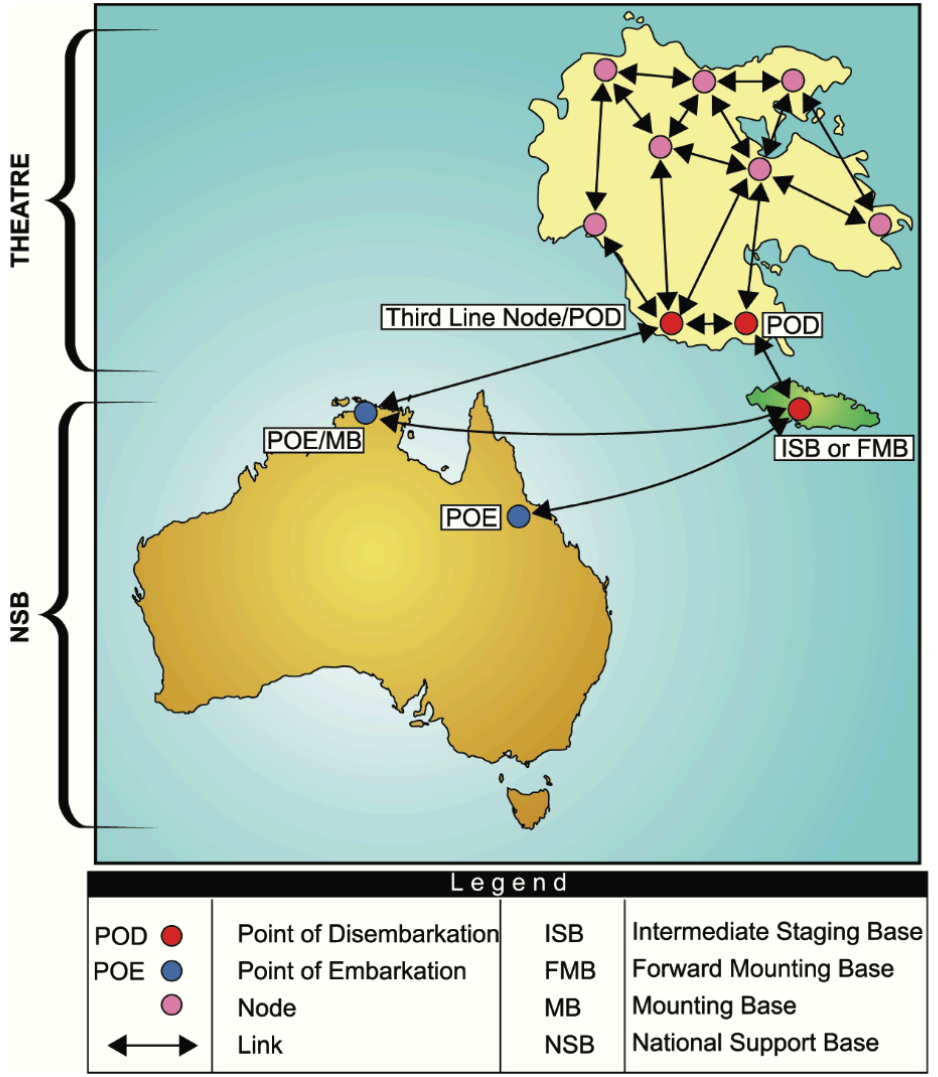
- Student project - ADFA
- Limited time frame (3 months)
- Aim: Develop a straw man (prototype) model in order to:
  - Assist stakeholders in providing meaningful data
  - Assist decision makers in seeing the potential for a larger model
  - Assist designers in refining requirements
- Followed the Modelling and Simulation developmental lifecycle detailed in Balci and Robinson
  - Verification and Validation was carried out throughout the process



# Problem Scoping and Formulation

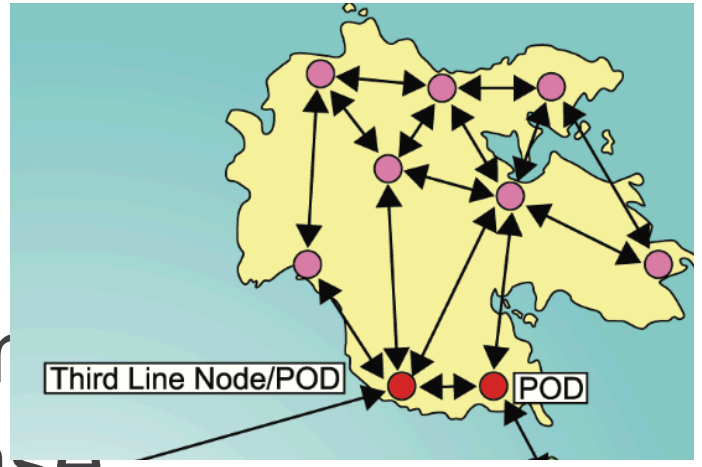
# Army logistics = All The Things

- From National Support Base to Operational Theatre
- Every function needed to sustain life and combat power
  - *Emergency equipment maintenance*
  - *Entire equipment replacement*
  - *Fast urgent replenishment into the battle*
  - *Long exposed convoys across dangerous and contested landscapes*
  - *Dangerous good distribution*
  - *Perishable goods distribution – blood, drugs, food*
  - *Water*
  - *Multiple fuel natures*
  - *Emergency medical care*
  - *Casualty evacuation*
  - *Patient transport*
  - *Welfare/psych support*
  - *Post*
  - *Grey and blackwater waste removal*
  - *Toilets and portaloos*
  - *Mortuary services*
  - *Decontamination*
  - *Local contracts*
  - *International contracts*
  - *Personnel movement*



# Constantly changing priorities

- Multiple Combat Teams and Battle groups
- Multiple Locations
- Multiple mission types:
  - Stability Operations,
  - Offensive operations, rapidly movin
  - Humanitarian Aid/Disaster Response
- Standard procedures deal with the normal
  - Black Swans must be anticipated



# It's not about the knowns... it's the unknowns

- Black Swans:
  - Slang for the uncertainties of war
  - **Theory**: Outliers - unforeseeable events of large magnitude and consequence, of low probability, often rationalised in hindsight
  - **Army logistics version**: Unknown unknowns: Low likelihood, high consequence risks that the inexperienced don't know how to prepare for
- Experienced logisticians know that
  - We have insufficient data, and cannot anticipate every risk
  - We have insufficient resources and cannot control or mitigate every risk
  - The art is in identifying what is critical, and prioritising resources to ensure that the critical path is robust – through flexibility or resilience
- Experience ~ being ready for Black Swans (even if they're not the Swans you were expecting)

# Adaptive Action / Assumption based planning

- Full knowledge of situation cannot exist before entry into theatre
- We must take action to stimulate systemic responses
- That system remains in a constant state of flux
- Not an optimisation problem, but a problem of constant adaptation (and knowing when not to change).
- Therefore Logistic planners must:
  - know how to make reasonable assumptions so they can plan with limited information
  - learn, in each new mission, how to learn what is important
  - learn how to monitor /measure what is important
  - interpret the response, and understand what should be done
  - know *when* to change, and when change would be more disruptive than beneficial

# Problem scoping: Observations

- Logisticians are taught how to construct a plan (at generic level), but not how to develop internal validation measures, or how to ensure their plan adapts appropriately/is resilient to unforeseen events (the nature of war)
- Problem changes over time as new situations emerge within the complex adaptive system

- Dynamic complexity obscures ability to for army logisticians to improve mental model.
- Therefore any model needs to accept substantial simplification to be workable as a teaching tool
- Experienced logisticians know that it's not the expected, but the Black Swans that challenge logistic planning.

- **The training problem is conceptual, not procedural...** about how to learn what you need to know, not "what to think" - therefore the model should elevate lessons learned into principles of thinking, not simply 'mission-specific lessons learned'.

# Design and Validation Challenges

# Stakeholder engagement

- Workshops, informal interviews
- Stakeholders
  - Logistic officers – different levels experience, deployment history, command history
  - Past (qualified) instructors
  - Potential users/students

  (often the same people)

# Stakeholder observations

- Cultural/personality characteristics
  - Limited experience with simulation
  - Have generally performed as planners, commanders, instructors and been students...
  - Well versed in issues of risk, and of probability distributions of outcomes, but
  - Difficulty expressing concepts in quantitative terms needed for modelling

- They have *lived* the consequences
  - Reflection coloured by emotion (and reasonably so)
  - Skews perception of relative importance (the Toilet Paper effect)
  - Fixation on hyper-accuracy (inaccuracy feels personally confronting)
  - Conflate personal experience with all experience (THE war vs A war)

  - But...Vested interest in training next generation

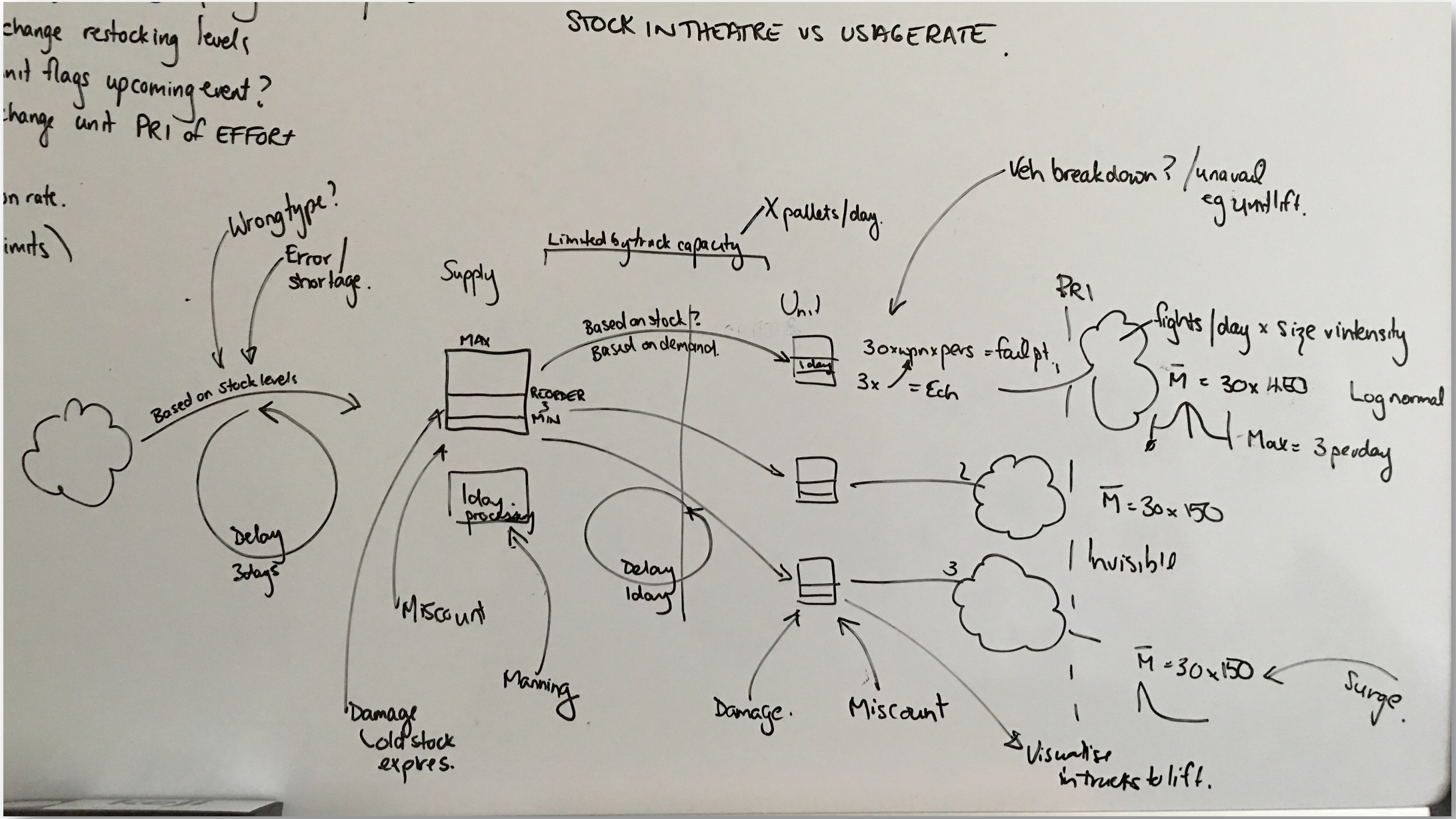
# Managing Model complexity

- Balancing model complexity and learning effects
  - Simplifications to model to single function with only a daily iteration.
  - Ammunition: well known, hard to predict and psychologically *important*.
  - Removed many real-life constraints (eg infinite number of delivery trucks, drivers never need sleep, Battlegroups don't move)
  - "Enemy effects" reduced to a black box function
  - Limited Black Swans
- Balancing psychological desire for completeness/accuracy with learning effects
  - Users highly sensitive to inaccuracy vs their personal experience
  - Conversely, some exaggeration is embraced as "necessary to deliver the lesson"

- *Balancing model complexity with limitations of model designer (me)*

# Conceptual Modelling - Elicitation

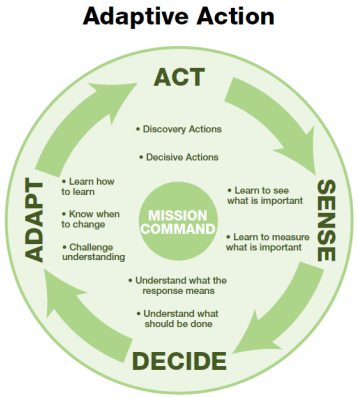
- Developed a very simple excel-based model using doctrinal planning rates, and provisioning policies (familiar to users) to confirm basic concepts
  - System dynamic flows (the supply chain functioning normally)
  - Most likely Black Swan events (contradiction in terms)
  - Identified and developed concept for agent behaviour
  - Quantified boundaries, such as
    - “what is the maximum amount of ammunition a Battlegroup of X size could consume, before the entire example would become invalid (eg before they would simply withdraw or be reinforced ”,
    - “what is the maximum stockholding we could ask a unit to hold before we’ve created a risk of losing ammunition to enemy action”
- A lot of white-boarding to map flows and understanding....


change restocking levels
nit flags upcoming event?
change unit PRI of EFFORT
on rate.
imits)
STOCK IN THEATRE VS USAGE RATE.
Wrong type?
Error / shortage.
Based on stock levels
Delay 3days
Supply
Limited by track capacity
X pallets/day.
MAX
REORDER 3 MIN
Based on stock?
Based on demand.
1day processing
Miscount
Manning
Damage
Cold stock expires.
Delay 1day
Unit
Veh breakdown? / unavail eg unit lift.
1day
30 x ups x pers = fail pt.
3x
= Ech
PRI
flights/day x size x intensity
M = 30 x 450
Log normal
Max = 3 per day
2
M = 30 x 150
Invisible
3
M = 30 x 150
Surge.
Damage.
Miscount
Visualise in trucks to lift.

# Developing Hybrid Model Design

- **System Dynamics** – use seemed self evident – reflects doctrine on the "rules" of supply chain management

- **Agent Based Modelling** – specifically addresses the cognitive challenge presented by ASDA - Assumption Based Planning
  - Represents the various actors a planner would engage
  - Aligns very well to specific logistic planning processes
  - Allows efficient modelling of the Black Swan events



# Observations on V&V

- Stakeholders gave contradictory feedback on suitability & acceptability
- Credibility more important than accuracy
  - Less realistic data, but which generated a teaching moment was accepted
  - Presenting data as charts or graphics essential to permit this “suspension of disbelief”
  - Certain data must be visible, as user would expect to see it and conduct ‘back of envelope’ calculations
- Interpretation was essential – being able to see cause and effect
  - In prototype this still requires an instructor, to help user/stakeholder understand the learning outcome –
  - Therefore a final model would need to seamlessly show
    - First order effects
    - Second order effects
    - Procedural vs tactical decisions
    - Link to related/networked planning considerations
    - Prompts to act

# The model

# Prototype Scenario / Use Case

*A **Combat Service Support Battalion (CSSB**) is deployed into a combat theatre and is responsible for providing ammunition supply support (a single nature of rifle ammunition) to **three battlegroups (BG)** in three different locations. Each BG is of a different size and is subject to variable usage rates which are determined by how frequently they engage with the enemy and the severity of the contact. The CSSB is responsible for ensuring that the BG ammunition holdings never drop below a set minimum holding*

Agents

*Ammunition is delivered to the CSSB from a higher level supply source based on fixed rules. This is an unlimited supply but there is a delay between order and delivery of ammunition to the CSSB. This generates a risk of forecasting error. The CSSB has an unlimited number of transport assets available to achieve delivery of the ammunition regardless of the ammunition usage.*

System Dynamic Flow

*The BG minimum holding represents the failure point – it is the stock level below which the BG is at unacceptable risk of overwhelming defeat.*

Win/Lose

Project Caesar : Simulation - AnyLogic PLE [PERSONAL LEARNING USE ONLY]

x2 experiment: Pro...

# Ammunition in Syria

Run

Your challenge: manage the 5.56mm ball ammunition supply to 3 different battlegroups:
BGNorth, BG Central and BG South

Enemy happens  Accidents happen

BG North Init Pers 650

BG Central Init Pers 720

BG South Init Pers 310

For simplicity, and to keep this simulation UNCLASS, you are to assume a conversion rate of:
0.0015 pallets/pers = First Line holdings = Minimum stock holdings
All qties will be shown as pallets of ammunition

Mean average usage rates are provided but the Enemy doesn't conform to our "planned" rates.
Also, accidents happen...

**Run:** 0 Idle | **Time:** - | **Simulation:** Stop time not set | **Date:** -

Project Caesar : Simulation - AnyLogic PLE [PERSONAL LEARNING USE ONLY]

x2 experiment: Pro.. AnyLogic

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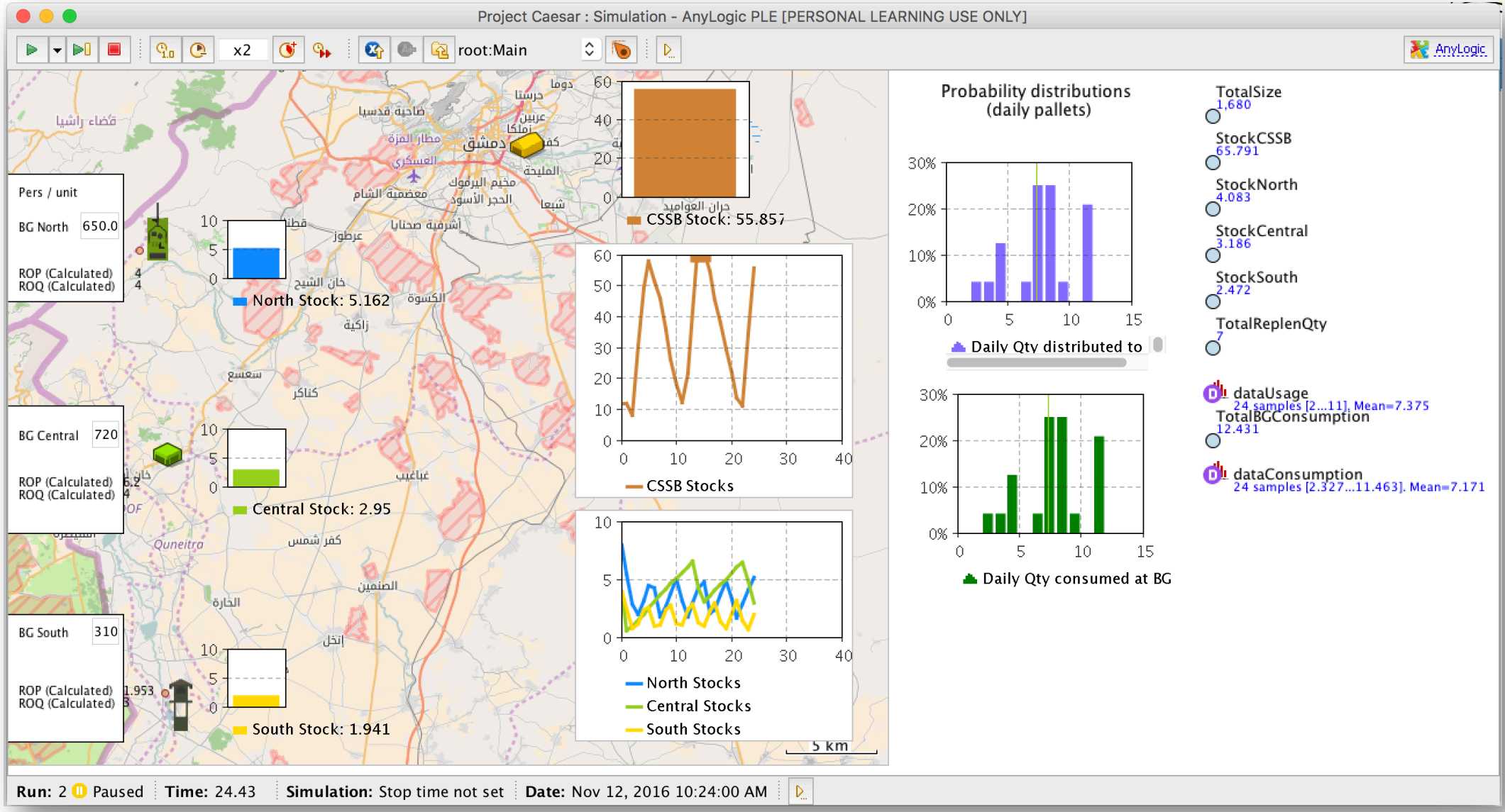
**Run:** 5 Idle | **Time:** - | **Simulation:** Stop time not set | **Date:** -


Project Caesar : Simulation - AnyLogic PLE [PERSONAL LEARNING USE ONLY]
x2
root:Main
AnyLogic
Pers / unit
BG North 650.0
ROP (Calculated)
ROQ (Calculated)
BG Central 720
ROP (Calculated)
ROQ (Calculated)
BG South 310
ROP (Calculated)
ROQ (Calculated)
North Stock: 5.162
Central Stock: 2.95
South Stock: 1.941
CSSB Stock: 55.857
CSSB Stocks
North Stocks
Central Stocks
South Stocks
5 km
Probability distributions
(daily pallets)
Daily Qty distributed to
Daily Qty consumed at BG
TotalSize
1,680
StockCSSB
65.791
StockNorth
4.083
StockCentral
3.186
StockSouth
2.472
TotalReplenQty
7
dataUsage
24 samples [2...11], Mean=7.375
TotalBGConsumption
12.431
dataConsumption
24 samples [2.327...11.463], Mean=7.171
Run: 2 Paused
Time: 24.43
Simulation: Stop time not set
Date: Nov 12, 2016 10:24:00 AM

# What Next?

# Army logisticians need a simulation model

- Army needs an engaging model which offers experimentation and reflection on experience
- The essential focus is not hyper-fidelity to an actual war, but
  - how to see what is important
  - how to measure what is important
  - understand what should be done
  - know when to change

# End state (Main Model)

- Game characteristics
  - Serious game containing dynamically complex model of “A war”
  - Many scenarios to reduce inadvertent fixation on specifics of a mission.
  - Self-teaching (learn by playing) – (low cost of operation)
  - Engaging gameplay (self-motivating)

- Student learning outcomes:
  - Interaction between various logistics functions
  - Feedback loops made overt to better understand dynamic complexity
  - Students can visualise consequences of planning decisions/shortfalls
  - Students gain experience in adapting their plan to long /short range events

# Reflections on developing a main model

- This prototype is a vast oversimplification, but is already a teaching tool
- Uncertainty is inherent in war, and there is simply no data on many of the events we would seek to model.
- A future model must reflect these uncertainties, and provide the user with opportunities to learn how to make assumptions and adjust plans
- Model interactivity is essential, especially
  - an interface which rewards correct behaviours and does not inadvertently reinforce poor behaviours,
  - engaging functionality, and
  - exposure to realistic consequences (Scar tissue)

# Developing the main model

- A more comprehensive model would include the main logistic methods (supply, maintenance, distribution and health) and how these networks interact
- A hybrid model will be highly desirable for matching the procedural element with the decision making cognitive skills
- A serious game is likely to be the most acceptable vehicle to both individual students and defence training establishments

# Ways to extend

- More detailed exploitation of the geographic environment to introduce challenges of distance, time and terrain
- Introduction of more clearly defined Black Swan events
- Additional agents, such as enemy, weather, trucks or individual (mission critical) specialists
- Develop the Graphic User Interface
- Experimentation with military personnel and cognitive skills specialists.

# Ideal

- Compare and contrast this with commercial off the shelf city building and strategy games
- Compare/align with current Defence consideration of into constructive, human in the loop simulation
- Deliver a game that is UNCLAS, independent of Australian needs (and of ADF restrictive information system requirements) , but which reinforces identification of critical paths & nodes and appropriate adaptation and response

# My ideal...


# Key References:


- Balci, O, "**A life cycle for modeling and simulation**". Simulation, 88(7), pp 870-883
- Sterman, JD, 1994 "**Learning in and about complex systems**". *System Dynamics Rev*iew, 10(2-3), pp 291-330
- **Army's Future Land Operating Concept (ACFLOC)** – Commonwealth of Australia, 2009 (www.army.gov.au)
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